

# **THE EFFECT OF NATURAL AND MANMADE WATER TEMPERATURE VARIATION ON CHINOOK SALMON EGG SURVIVAL AND DEVELOPMENT**

**#0071**

# Technical Panel Review

*Proposal Name:* THE EFFECT OF NATURAL AND MANMADE WATER TEMPERATURE VARIATION ON CHINOOK SALMON EGG SURVIVAL AND DEVELOPMENT

*Applicant Organization:* California State University Sacramento

*Principal Lead Investigator(s):*  
Coleman, Ronald

*Amount Requested:* \$262,250

## *TSP Panel Summary of Findings:*

This is a clear, well-presented proposal to examine the relationship between temperature and mortality rates of Chinook eggs. However, a thorough justification for this work is lacking. While the relationship between temperature and salmon egg mortality requires elucidation, more is known regarding this relationship than the proposal implies. In addition, there are some concerns regarding the proposed methods (e.g., choosing eggs from the middle third of size distribution; not a complete design each year; procedure for delivery of mold to incubation tanks). Further, this is a relatively narrow project, and for the amount of funds requested, the research could explore other facets of the temperature/egg-mortality relationship. The panel questioned what new data this project would produce, and whether it would push the envelope. Finally, it would be beneficial for the proposed work to have more clear management linkages. In fact, better coordination with agency biologists and hatcheries could greatly improve upon and leverage the proposed research. This coordination could also benefit the budget, with such cost-sharing activities as partnering on or borrowing equipment (instead of purchasing new). In summary, the project proposes a fairly straight-forward idea that has potential benefits to management, but most reviewers felt that the project would not likely change our basic knowledge or understanding about this topic.

Technical Panel Review

***Relevance to PSP Topic Areas:***

**Low**

***TSP Technical Rating:***

**Inadequate**

***TSP Funding Recommendation:***

**Do Not Fund**

***TSP Amount Recommended:* \$0**

***Conditions:***

# External Technical Review #1

**Proposal Title:** THE EFFECT OF NATURAL AND MANMADE WATER TEMPERATURE VARIATION ON CHINOOK SALMON EGG SURVIVAL AND DEVELOPMENT

**Proposal Number:** 0071

**Proposal Applicant:** California State University Sacramento

## Purpose

Comments	<p>The goals, objectives and hypotheses are clearly stated and internally consistent. The idea is not timely and important. The study is not justified relative to existing knowledge. The selection of research is not justified. The results are not likely to add to the base of knowledge. The project is not likely to generate novel information, methodology, or approaches.</p> <p>The effects of water temperature on egg mortality are already well-defined - see US Fish and Wildlife Service (1999) Effect of temperature on early-life survival of Sacramento River fall and winter-run chinook salmon. Final Report. Northern Central Valley Fish and Wildlife Office, Red Bluff, CA, 41 pp.</p> <p>The US Bureau of Reclamation monthly chinook egg versus survival model indicates 0% survival for water temperatures up to 5 degrees Centigrade, 100% survival for water temperatures of 5 to 13.3 degrees Centigrade and declining survival as follows for water temperatures above 13.3 degrees Centigrade:</p> <p>Water Temp (degrees F) Survival</p>
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	<p>56 100.0%</p> <p>57 90.0%</p> <p>58 80.0%</p> <p>59 65.5%</p> <p>60 16.7%</p> <p>61 3.4%</p> <p>62 0.0%</p> <p>Water temperatures in the Lower American River in October through December (USGS Gage 11446500) range from 7.4 to 21.5 degrees Centigrade - thus, mortality due to temperature drops is not an issue.</p>
Rating	Inadequate

## Background

Comments	<p>A conceptual model is not clearly stated in the proposal. All other information needed to understand the basis for the proposed work is not included and well documented - particularly the above US Fish and Wildlife Service (1999) reference, the US Bureau of Reclamation monthly chinook egg versus survival model and information on what the existing water temperatures are in the Lower American River during fall-run chinook salmon egg development (ie October through December).</p>
Rating	Inadequate

## Approach

Comments	<p>The approach is well designed and appropriate for meeting the objectives of the project. It is clear who will be performing management tasks and administration</p>
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## External Technical Review #1

	of the project and are resources set aside to do so. Products of value are not likely from the project. There is a plan for widespread and effective dissemination of information gained from the project. Contributions to larger data management systems are relevant and considered.
Rating	Inadequate

## Feasibility

Comments	The approach is fully documented and technically feasible. The likelihood of success is high. The scale of the project is consistent with the objectives and within the grasp of authors.
Rating	Superior

## Budget

Comments	It is clear how much each aspect of the proposed work will cost including each task, salaries, equipment, etc. The budget is reasonable and adequate for the work proposed.
Rating	Superior

## Relevance To CALFED

Comments	The proposal addresses the priorities stated in the PSP. The proposal clearly and directly address one or more of the topics in the Priority Research Topic List. The proposal does not address other priorities stated in the PSP such as integration, syntheses, use of existing information, multiple disciplines or modeling. The information ultimately will not be useful to CALFED resource managers and policy makers.
Rating	Inadequate

## External Technical Review #1

### Qualifications

Comments	The track record of authors is good in terms of past performance. The project team is qualified to efficiently and effectively implement the proposed project. They have available the infrastructure and other aspects of support necessary to accomplish the project.
Rating	Superior

### Overall Evaluation Summary Rating

Comments	My summary rating is because the effect of water temperature on chinook salmon egg mortality is already well-defined, and thus the proposed research is not necessary.
Rating	Inadequate

# External Technical Review #2

**Proposal Title:** THE EFFECT OF NATURAL AND MANMADE WATER TEMPERATURE VARIATION ON CHINOOK SALMON EGG SURVIVAL AND DEVELOPMENT

**Proposal Number:** 0071

**Proposal Applicant:** California State University Sacramento

## Purpose

Comments	<p>The goals of the study are clearly stated but the idea is not very timely. The review of the existing literature is very poor, as many relevant studies are not cited. It is simply not correct that salmon biologists and hatchery managers use a simple thermal sums model. Papers published 20 years ago showed the more complex patterns.</p> <p>Beacham, T. D., and C. B. Murray. 1990. Temperature, egg size, and development of embryos and alevins of five species of Pacific salmon: a comparative analysis. Transactions of the American Fisheries Society 119:927-945.</p> <p>Beacham, T. D., and C. B. Murray. 1989. Variation in developmental biology of sockeye salmon (<i>Oncorhynchus nerka</i>) and chinook salmon (<i>O. tshawytscha</i>) in British Columbia. Canadian Journal of Zoology 67:2081-2089.</p> <p>Brannon, E. L. 1987. Mechanisms stabilizing salmonid fry emergence timing. Canadian Special Publication of Fisheries and Aquatic Sciences 96:120-124.</p> <p>Murray, C. B., and J. D. McPhail. 1988. Effect of incubation temperature on the development of five species of Pacific salmon (<i>Oncorhynchus</i>) embryos and alevins. Canadian Journal of Zoology 66:266-273.</p>
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## External Technical Review #2

	Rombough, P. J. 1985. Initial egg weight, time to maximum alevin wet weight, and optimal ponding times for chinook salmon ( <i>Oncorhynchus tshawytscha</i> ). Canadian Journal of Fisheries and Aquatic Sciences 42:287-291.
Rating	Inadequate

## Background

Comments	I think there are good reasons to want to know more about the incubation rate of chinook salmon but the author has not explained them to my satisfaction. The proposal amounts to a statement that "lots of embryos die and so anything we learn about them will be useful." Given the fact that we already know more about temperature, dissolved oxygen, flow rate and incubation of salmon than just about any other aspect of their biology, I think we need a better justification for more study.
Rating	Inadequate

## Approach

Comments	The basic approach is certainly feasible but it might be more interesting and useful to ramp the embryos through a natural temperature regime such as the one they experience in the river, and the ones that the river might show in the future. Indeed, there is no mention of the actual thermal experience of embryos, nor the details of when adults spawn and fry emerge. Thus the project's approach is not well linked to the natural history and management issues at hand.
Rating	Inadequate

## Feasibility

Comments	The project is feasible as proposed, just too narrow to be very useful.
Rating	Sufficient

## External Technical Review #2

### Budget

Comments	Sufficient
Rating	Sufficient

### Relevance To CALFED

Comments	The proposal does not make sufficient links to specific problems, nor is there a clear management action that might result from the work.
Rating	Inadequate

### Qualifications

Comments	The author has a good research record but no experience with salmon and trout. This might not be a problem if there had not been so many other weaknesses in the proposal. As it stands I think that further literature research is needed to make this proposal more relevant.
Rating	Sufficient

### Overall Evaluation Summary Rating

Comments	The project is really not well-justified in terms of conservation concerns, and the study design does not reflect the research that has been done on this subject.
Rating	Inadequate

# External Technical Review #3

**Proposal Title:** THE EFFECT OF NATURAL AND MANMADE WATER TEMPERATURE VARIATION ON CHINOOK SALMON EGG SURVIVAL AND DEVELOPMENT

**Proposal Number:** 0071

**Proposal Applicant:** California State University Sacramento

## Purpose

<b>Comments</b>	<p>The importance of this research should not be underestimated. It is frankly embarrassing that we have such a poor grasp on such an important part of the salmonid life history. This is particularly true because we actually have more control over incubation water temperatures than we do in most other parts of the salmonid life cycle. Furthermore, the author's study WILL produce some of the answers we need in relatively unambiguous format.</p> <p>I think the author could push the envelope a bit further in the time and with the money requested for this study. I also think there is the potential for collaboration with hatcheries (state or in other labs) that has not been explored (see below re: following fish grown at different temperatures further into their life cycle). However, I feel this research must be done soon before major decisions about water management In the American River, San Joaquin system, and elsewhere) have unintended consequences for California's Chinook salmon; thus, my comments (throughout) about how the proposal could be more ambitious are not intended as reasons to deny funding but rather as advice to the proponent and CBDA (should it fund this research).</p>
<b>Rating</b>	Superior

## Background

Comments	<p>The author makes a strong case that our knowledge of Chinook salmon incubation is wholly insufficient, particularly given the massive water management proposals on the table. The implicit conceptual model is that incubation success is a major determinant of Chinook salmon population levels. The author acknowledges that other factors (e.g. density dependent survival at later life stages) may mitigate for strong or weak incubation success; however it is not possible to compare these different conceptual models in this research proposal.</p> <p>The author really should have provided more background from the natural system to justify and support his choice of temperature regimes. I presume there are actual river temperature data for this river system and that there are temperature projections for different water management schemes. If not, there are certainly data from the Sacramento River to use as a model. This would allow the reader to see how the chosen temperature treatments are relevant to real-world situations.</p>
Rating	Sufficient

## Approach

Comments	<p>The approach is well described with the exception of an explanation of how "replicates" run off the same chiller will be statistically independent (see below). It is clear that the author and his students will be implementing the experiments and monitoring their results. Dissemination of the results appears well-planned through important outlets. Data generated from this study have the potential to be extremely important and will certainly be used in our system and elsewhere to make ecologically and economically important decisions.</p>
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One potential problem is that the author proposes that 8 "replicates" of each temperature treatment will be run by a single chiller (2 chillers per temperature). However, if the water that is circulated between the 8 replicates is intermingled (i.e. fed from a common chiller), then the 8 replicates are not independent of each other. This is particularly important for the measurement of infectious diseases (e.g. mold) as the author proposes.

Pending further clarification, I am willing to assume that the chiller system will not exchange water between different replicates and that these replicates will thus be statistically independent. If this is the case, I think the author proposes too many replicates. Given the expensive and space-limiting nature of the equipment, the author could be satisfied with as few as five replicates of each treatment. Reducing the number of replicates should be used to increase the scope of the project because there are many questions regarding temperature and salmon incubation that MUST be answered.

If the chillers can actually run 8 truly independent replicates, there is no need to have two of them running the same treatment at once over two years. I understand that the equipment might fail, ruining up to 8 replicates; but, if they can get 5-8 replicates at each temperature, they should have very robust results. There will be at least two years to get data from these replicates.

I am not clear what the proposed 2nd year experiments will show. The dynamics of mold growth are related to more than just temperature. This seems to be one of those effects where the translation between lab results and field results would be difficult. Replication may, again, be a problem. For example, how do the mold spores get into the experimental system? Is it found in the water that will be used as a source for the different "replicates"? Or is it a common

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	<p>airborn spore? In either of these cases, the replicates must receive exactly the same exposure to mold spores in order to analyze the effect of temperature on mold growth on the eggs. I suggest maintaining the UV system throughout years of the experiment to explore other questions (see below).</p> <p>I am concerned about the method of choosing eggs from the middle 1/3 of the egg size range. Eggs of different sizes may develop at different rates. This may in fact be a part of the chinook salmon life history "strategy". Early work (by Thorgaard and others) suggests that the salmonid bet-hedging strategy extends to the level of the individual in that one individual produces offspring that follow several different life-history paths. This increases the odds of at least some reproductive success. Eggs of different sizes that develop differently may be a way for Chinook salmon to "game" the natural environment. It would be very interesting to know whether the different temperatures studies produce different responses among eggs of different sizes. This would allow one to predict reproductive success at the individual level and to detect whether different water operations scenarios actually exert selective pressure for a certain type of life history. Finally, different females are known to produce different size-ranges of eggs and, by selecting only eggs that are in the middle 1/3 of the "egg population", the author may inadvertently reduce the number of "parents" contributing to the study and thereby reduce the statistical power of the analysis.</p>
Rating	Above Average

### Feasibility

Comments	The project is consistent with the objectives and within the grasp of the author. It is completely feasible and likely to generate very specific and useful results. Indeed, I really feel that the authors could accomplish
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more in the time and with the money they are requesting.

If all replicates are successful (and I know from experience that that is not entirely likely), the author would have 32 replicates at each of 7 temperatures (half of the replicates would be with a UV system in operation and half would be without that system). IF truly important differences exist between temperature treatments, I would expect the author to be able to detect such differences with fewer replicates. Usually, I would be in favor of conducting more replicates but, here I see the potential to answer many other important questions about Chinook salmon incubation -- these could be answered if the author was more ambitious in his research program for this proposal.

For example, I feel like the question identified above re: the response of different size eggs to different temperature scenarios would be an interesting product of this project and one that could really help us understand the life-history and selective ramifications of different water management schemes.

Another extremely important spin on this research that the author could consider is comparing the temperature response of different runs of Chinook salmon. Given their different spawning habitats and run timings, one might expect them to have a different response to different temperatures. These differences have been hypothesized but not studied in a controlled manner.

Although I think the data generated by this experiment are sorely needed, I would like to

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	<p>see the research go beyond the simple "egg mortality-curve" structure proposed here. Again, mortality is certainly worth studying and the effect of temperatures in the range proposed is likely to be important. But, I would expect the sublethal impacts of water temperature variation to be more important than all but the extreme temperature variations. Salmonid life histories are tremendously flexible and there appears to be a great amount of ecophenotypic variation. Rearing conditions are thus likely to produce important differences in growth rate, migration timing, and survival among *surviving eggs* (i.e. those that hatch). These differences are likely to play an important role in determining the effect of water temperature changes that happen as a result of water facility operations. The author could study survival to and size at swim-up instead of just egg survival. Perhaps, some of the fry that are reared under these different temperatures could then be tagged (physically or chemically) and followed on their downstream migrations? At the very least, their growth in the laboratory could be followed after mixing in common "rearing" conditions. This would reveal the subtle and sub-lethal effects on growth and behavior caused by different rearing temperature conditions.</p>
Rating	Superior

### Budget

Comments	<p>As described elsewhere in this review, I think the author could try to answer more questions with the money he has requested. By conducting fewer replicates or collaborating with hatcheries, the author might be able to extend his studies and really nail down some other serious questions about Chinook incubation</p>
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	(different sized eggs, different runs, post-hatching effects, etc.). Alternatively, the proposed project goals could be attained in two years of study -- at 67% of the current asking price, the information provided by such a study would be a very good value.
<b>Rating</b>	Sufficient

### Relevance To CALFED

	<p>The project is clearly relevant to CALFED's overall goals and specifically to the goals of this proposal solcitation.</p> <p>The proposal has obvious relevance to these categories: Environmental Water; Trends and Patterns of Populations and System Response to a Changing Environment; Habitat Availability and Response to Change</p>
<b>Comments</b>	The proposal could be EVEN MORE relevant by adding additional quetions to the initial proposal (see above). I am sensitive to the author's need to "do one thing well" but the answers to several different questions are badly needed. I don't think it would stretch the author too much to compare races or compare response of different egg size. I think following the hatched alevins to study their growth rate and behavior are well within the authors capacities regardless of either of the two additional studies I proposed here.
<b>Rating</b>	Above Average

### Qualifications

<b>Comments</b>	The author is well prepared to execute this research. His admittedly limited experience with Salmonid eggs will not be a problem. The researcher clearly has experience with the technology adn their are plenty of knowledgeable people who can help him learn what he needs to know to rear salmon eggs. His experience with
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	one of the world's leading authorities on salmon life histories will serve him well.
Rating	Superior

### Overall Evaluation Summary Rating

Comments	<p>This research will provide important information regarding a vital part of CALFED's management priorities. As I said earlier, it is an embarrassment that we still don't understand the particular temperature requirements of the Sacramento System's Chinook salmon. Changes of just 1 degree in water temperature can have vast consequences on incubation success and also cost 10's of millions of dollars. This project can produce insight into the cost:benefit of water management decisions with big consequences.</p> <p>That said, I truly believe the author and his team could accomplish more with three years of funding that he has requested OR the project could be funded for one less year and produce results of almost the same value as those proposed here. I encourage CBDA to work with this author to design a study that answers SEVERAL pressing questions about salmonid incubation success in relation to temperature and water management -- such a set of studies is BADLY needed and would be relatively cheap to conduct.</p>
Rating	Above Average